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1 [Level set and PDE methods for computer graphics](#)



David Breen, Ron Fedkiw, Ken Museth, Stanley Osher, Guillermo Sapiro, Ross Whitaker

 August 2004 **Proceedings of the conference on SIGGRAPH 2004 course notes GRAPH '04**

Publisher: ACM Press

 Full text available: [pdf\(17.07 MB\)](#) Additional Information: [full citation](#), [abstract](#)

Level set methods, an important class of partial differential equation (PDE) methods, define dynamic surfaces implicitly as the level set (iso-surface) of a sampled, evolving nD function. The course begins with preparatory material that introduces the concept of using partial differential equations to solve problems in computer graphics, geometric modeling and computer vision. This will include the structure and behavior of several different types of differential equations, e.g. the level set eq ...

2 [Projectors: advanced graphics and vision techniques](#)



Ramesh Raskar

 August 2004 **Proceedings of the conference on SIGGRAPH 2004 course notes GRAPH '04**

Publisher: ACM Press

 Full text available: [pdf\(6.53 MB\)](#) Additional Information: [full citation](#)

3 [Link and channel measurement: A simple mechanism for capturing and replaying wireless channels](#)



Glenn Judd, Peter Steenkiste

 August 2005 **Proceeding of the 2005 ACM SIGCOMM workshop on Experimental approaches to wireless network design and analysis E-WIND '05**

Publisher: ACM Press

 Full text available: [pdf\(6.06 MB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [index terms](#)

Physical layer wireless network emulation has the potential to be a powerful experimental tool. An important challenge in physical emulation, and traditional simulation, is to accurately model the wireless channel. In this paper we examine the possibility of using on-card signal strength measurements to capture wireless channel traces. A key advantage of this approach is the simplicity and ubiquity with which these measurements can be obtained since virtually all wireless devices provide the req ...

Keywords: channel capture, emulation, wireless

4 Special issue: AI in engineering



D. Sriram, R. Joobbani

April 1985 **ACM SIGART Bulletin**, Issue 92

Publisher: ACM Press

Full text available: [pdf\(8.79 MB\)](#) Additional Information: [full citation](#), [abstract](#)

The papers in this special issue were compiled from responses to the announcement in the July 1984 issue of the SIGART newsletter and notices posted over the ARPAnet. The interest being shown in this area is reflected in the sixty papers received from over six countries. About half the papers were received over the computer network.

5 Terrain database interoperability issues in training with distributed interactive simulation



Guy A. Schiavone, S. Sureshchandran, Kenneth C. Hardis

July 1997 **ACM Transactions on Modeling and Computer Simulation (TOMACS)**, Volume 7 Issue 3

Publisher: ACM Press

Full text available: [pdf\(443.34 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#), [review](#)

In Distributed Interactive Simulation (DIS), each participating node is responsible for maintaining its own model of the synthetic environment. Problems may arise if significant inconsistencies are allowed to exist between these separate world views, resulting in unrealistic simulation results or negative training, and a corresponding degradation of interoperability in a DIS simulation exercise. In the DIS community, this is known as the simulator terrain database (TDB) correlation problem. ...

Keywords: distributed interactive simulation, terrain databases

6 Technical session 12: intriguing applications: Incremental detection of text on road signs from video with application to a driving assistant system



Wen Wu, Xilin Chen, Jie Yang

October 2004 **Proceedings of the 12th annual ACM international conference on Multimedia**

Publisher: ACM Press

Full text available: [pdf\(678.16 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [index terms](#)

This paper proposes a fast and robust framework for incrementally detecting text on road signs from natural scene video. The new framework makes two main contributions. First, the framework applies a Divide-and-Conquer strategy to decompose the original task into two sub-tasks, that is, localization of road signs and detection of text. The algorithms for the two sub-tasks are smoothly incorporated into a unified framework through a real time tracking algorithm. Second, the framework provides ...

Keywords: driving assistant system, incremental text detection, natural scene video, road sign

7 Frontmatter (TOC, Letters, Philosophy of computer science, Interviewers needed, Taking software requirements creation from folklore to analysis, SW components and product lines: from business to systems and technology, Software engineering survey)



September 2005 **ACM SIGSOFT Software Engineering Notes**, Volume 30 Issue 5

Publisher: ACM Press

Full text available:  [pdf\(1.98 MB\)](#) Additional Information: [full citation](#)

8 Wireless integrated network sensors



G. J. Pottie, W. J. Kaiser

May 2000 **Communications of the ACM**, Volume 43 Issue 5

Publisher: ACM Press

Full text available:  [pdf\(303.43 KB\)](#)  [html\(40.24 KB\)](#) Additional Information: [full citation](#), [references](#), [citations](#), [index terms](#)

9 An extensible approach to imagery of gridded data



Geoffrey Dutton

July 1977 **ACM SIGGRAPH Computer Graphics , Proceedings of the 4th annual conference on Computer graphics and interactive techniques SIGGRAPH '77**, Volume 11 Issue 2

Publisher: ACM Press

Full text available:  [pdf\(3.19 MB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#)

A program offering a variety of cartographic techniques for mapping gridded data is described. Dot-distribution maps, several forms of contour maps and screen-toned maps are currently implemented for plotter and vector CRT. The structure and logic of the program is discussed and illustrated. The approach requires only local access to a data grid in a paging environment, allowing large data sets to be manipulated. Maps output may be plotted at any scale, irrespective of the size of the plotting d ...

Keywords: analytic hill-shading, cartography, contour mapping, device independence, dot-distribution mapping, gridded data, halftone imagery, inclined contour mapping, spatial analysis, spatial gradients, thematic mapping, vector graphics, virtual graphics, virtual memory

10 Conference abstracts



January 1977 **Proceedings of the 5th annual ACM computer science conference**

Publisher: ACM Press

Full text available:  [pdf\(3.14 MB\)](#) Additional Information: [full citation](#), [abstract](#), [index terms](#)

One problem in computer program testing arises when errors are found and corrected after a portion of the tests have run properly. How can it be shown that a fix to one area of the code does not adversely affect the execution of another area? What is needed is a quantitative method for assuring that new program modifications do not introduce new errors into the code. This model considers the retest philosophy that every program instruction that could possibly be reached and tested from the ...



11 Improving static and dynamic registration in an optical see-through HMD



Ronald Azuma, Gary Bishop

July 1994 **Proceedings of the 21st annual conference on Computer graphics and interactive techniques**

Publisher: ACM Press

Full text available:  [pdf\(321.33 KB\)](#)  [ps\(1.65 MB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

In Augmented Reality, see-through HMDs superimpose virtual 3D objects on the real

world. This technology has the potential to enhance a user's perception and interaction with the real world. However, many Augmented Reality applications will not be accepted until we can accurately register virtual objects with their real counterparts. In previous systems, such registration was achieved only from a limited range of viewpoints, when the user kept his head still. This paper offers improved regi ...

Keywords: augmented reality, calibration, registration

12 An EyeTap video-based featureless projective motion estimation assisted by gyroscopic tracking for wearable computer mediated reality

Chris Aimone, James Fung, Steve Mann

October 2003 **Personal and Ubiquitous Computing**, Volume 7 Issue 5

Publisher: Springer-Verlag

Full text available:  [pdf\(717.70 KB\)](#) Additional Information: [full citation](#), [abstract](#), [citations](#), [index terms](#)

In this paper we present a computationally economical method of recovering the projective motion of head mounted cameras or EyeTap devices, for use in wearable computer-mediated reality. The tracking system combines featureless vision and inertial methods in a closed loop system to achieve accurate robust head tracking using inexpensive sensors. The combination of inertial and vision techniques provides the high accuracy visual registration needed for fitting computer graphics onto real images a ...

Keywords: Augmented reality, Drift correction, EyeTap, Hybrid tracking, Mediated reality, Video head tracking

13 Paper session DB-8 (databases): query optimisation: Query workload-aware overlay construction using histograms

Georgia Koloniari, Yannis Petrakis, Evaggelia Pitoura, Thodoris Tsotsos

October 2005 **Proceedings of the 14th ACM international conference on Information and knowledge management CIKM '05**

Publisher: ACM Press

Full text available:  [pdf\(238.28 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [index terms](#)

Peer-to-peer(p2p) systems over an efficient means of data sharing among a dynamically changing set of a large number of a tonomous nodes.Each node in a p2p system is connected with a small number of other nodes thus creating an overlay network of nodes. A query posed at a node is routed through the overlay network towards nodes hosting data items that satisfy it. In this paper, we consider building overlays that exploit the query workload so that nodes are clustered based on their results to a g ...

Keywords: clustering, overlay network, peer-to-peer systems, query routing, range queries, small worlds

14 Real-time vision-based camera tracking for augmented reality applications

Dieter Koller, Gudrun Klinker, Eric Rose, David Breen, Ross Whitaker, Mihran Tuceryan

September 1997 **Proceedings of the ACM symposium on Virtual reality software and technology**

Publisher: ACM Press

Full text available:  [pdf\(1.20 MB\)](#) Additional Information: [full citation](#), [references](#), [citations](#), [index terms](#)

15

3D Galatea: Entry of three-dimensional moving points from multiple perspective

**views**

Steven A. MacKay, Richard E. Sayre, Michael J. Potel

July 1982 **ACM SIGGRAPH Computer Graphics , Proceedings of the 9th annual conference on Computer graphics and interactive techniques SIGGRAPH '82**, Volume 16 Issue 3

Publisher: ACM Press

Full text available: [pdf\(1.57 MB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

We describe an interactive graphics system for the entry of three-dimensional moving points from multiple perspective views. This work represents a major extension of Galatea, our system for graphics-assisted 2D motion analysis. 3D Galatea permits reconstruction of 3D time-dependent positions from 2D entries in two or more perspective views. The system supports a general approach for calibrating perspective views. This method, based on work of Sutherland, uses a known 3D referenc ...

16 Vertical handoffs in wireless overlay networks

Mark Stemm, Randy H. Katz

December 1998 **Mobile Networks and Applications**, Volume 3 Issue 4

Publisher: Kluwer Academic Publishers

Full text available: [pdf\(770.58 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

No single wireless network technology simultaneously provides a low latency, high bandwidth, wide area data service to a large number of mobile users. Wireless Overlay Networks – a hierarchical structure of room-size, building-size, and wide area data networks – solve the problem of providing network connectivity to a large number of mobile users in an efficient and scalable way. The specific topology of cells and the wide variety of network technologies that comprise wireless o ...

17 Visual registration for unprepared augmented reality environments

Ke Xu, Simon J. D. Prince, Adrian David Cheok, Yan Qiu, Krishnamoorthy Ganesh Kumar

October 2003 **Personal and Ubiquitous Computing**, Volume 7 Issue 5

Publisher: Springer-Verlag

Full text available: [pdf\(902.04 KB\)](#) Additional Information: [full citation](#), [abstract](#), [index terms](#)

Despite the increasing sophistication of augmented reality (AR) tracking technology, tracking in unprepared environments still remains an enormous challenge according to a recent survey. Most current systems are based on a calculation of the optical flow between the current and previous frames to adjust the label position. Here we present two alternative algorithms based on geometrical image constraints. The first is based on epipolar geometry and provides a general description of the constraint ...

Keywords: Augmented reality, Fundamental matrix, Homography, Optical flow, Vision based tracking

18 Resilient overlay networks

David Andersen, Hari Balakrishnan, Frans Kaashoek, Robert Morris

October 2001 **ACM SIGOPS Operating Systems Review , Proceedings of the eighteenth ACM symposium on Operating systems principles SOSP '01**, Volume 35 Issue 5

Publisher: ACM Press

Full text available: [pdf\(1.50 MB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#), [review](#)

A Resilient Overlay Network (RON) is an architecture that allows distributed Internet applications to detect and recover from path outages and periods of degraded

performance within several seconds, improving over today's wide-area routing protocols that take at least several minutes to recover. A RON is an application-layer overlay on top of the existing Internet routing substrate. The RON nodes monitor the functioning and quality of the Internet paths among themselves, and use this information ...

19 Three-dimensional medical imaging: algorithms and computer systems



M. R. Stytz, G. Frieder, O. Frieder

December 1991 **ACM Computing Surveys (CSUR)**, Volume 23 Issue 4

Publisher: ACM Press

Full text available: pdf(7.38 MB)

Additional Information: [full citation](#), [references](#), [citations](#), [index terms](#), [review](#)

Keywords: Computer graphics, medical imaging, surface rendering, three-dimensional imaging, volume rendering

20 An entity maintenance and connection service for sensor networks



Brian Blum, Prashant Nagaraddi, Anthony Wood, Tarek Abdelzaher, Sang Son, Jack Stankovic

May 2003 **Proceedings of the 1st international conference on Mobile systems, applications and services MobiSys '03**

Publisher: ACM Press

Full text available: pdf(294.88 KB) Additional Information: [full citation](#), [abstract](#), [references](#)

In this paper, we present a middleware architecture for coordination services in sensor networks that facilitates interaction between groups of sensors which monitor different environmental events. It sits on top of the native routing infrastructure and exports the abstraction of mobile communication endpoints maintained at the locations of such events. A single logical destination is created and maintained for every environmental event of interest. Such destinations are uniquely labeled and can ...

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Wireless Data Communications - by Pahlavan - 93 citations

Control of overlay registration patent

The method comprises estimating a state using **moving horizon estimation** and determining an input of the **registration overlay** using the state. ...

www.freshpatents.com/Control-of-overlay-registration-dt20050421ptan20050083243.php
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Control of overlay registration patent

[0014] An improved technique for controlling **registration overlay** is disclosed. In some embodiments, the system performs a **moving horizon estimation** to ...

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US Pregrant 20050083243 - Control of overlay registration

A system and method are disclosed for controlling a **registration overlay**. The method comprises estimating a state using **moving horizon estimation** and ...

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2003 IEEE CONFERENCE ON CONTROL APPLICATIONS

Moving Horizon State Estimation of Hybrid Systems. ... Performance Evaluation of Run-to-Run Control Methods in **Semiconductor** Processes, Chang Zhang, ...

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Control of overlay registration

A system and method are disclosed for controlling a registration overlay. The method includes estimating a state using moving horizon estimation and determining an input of the registration overlay using the state. The system comprises an estimator configured to determine the state using moving horizon estimation; and a regulator configured to determine an input of the registration overlay using the state.

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Agent: [Van Pelt & Yi LLP](#) - Cupertino, CA, US

Inventor: [Scott A. Middlebrooks](#)

Class: 343797000 (USPTO), H01L021/00 (Intl Class)

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FIELD OF THE INVENTION

[0001] The present invention relates generally to semiconductor processing. More specifically, a registration overlay registration control technique is disclosed.

BACKGROUND OF THE INVENTION

[0002] Semiconductor devices are commonly fabricated using lithography technique of material are deposited onto or etched away from a wafer to form devices and circuit patterns. After a layer of material is deposited or etched and before the wafer is further processed, the wafer is measured and realigned with an alignment tool to reduce any errors resulting from process variations. As semiconductor devices shrink in size, the requirements for controlling the misalignment become more stringent. Many systems in existence today employ an overlay registration technique to reduce overlay misalignment errors.

[0003] FIG. 1 is a diagram illustrating a wafer used in an overlay registration process. The wafer includes a number of dies 102. On each die, there are a number of test patterns 106.

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there are four test patterns that are measured by the alignment tool, resulting in four misalignment vectors 104. The misalignment vectors are typically calculated as the sum of the interfield errors (also referred to as grid errors) and intrafield errors (also referred to as intrafield errors).

[0004] In Proceedings of SPIE, Microlithography 2003, 5044-2 entitled "OPTIMAL PREDICTIVE CONTROL OF OVERLAY LITHOGRAPHY IMPLEMENTED IN A MICROPROCESSOR" by Scott Middlebrooks, which is incorporated herein by reference for all purposes, Middlebrooks describes a model predictive controller that estimates system states and regulates the system to desired targets. The controller employs a Kalman filter to estimate the current system states given measured outputs. Given an optimal estimate, a regulator is used to drive the system states to desired targets. The controller attempts to reject the process disturbance input move, and is known as a "deadbeat" controller.

[0005] Although this deadbeat controller, which includes using a Kalman filter for estimating system states, is useful in misalignment correction, several issues remain. It would be useful to account for the constraints of the system, such as the range of valid inputs, and states. A common approach to handling values that are out of bound is to clip these values; however, clipping results in sub-optimal selection of values. Although estimating states using a Kalman filter works well for linear systems, it may introduce errors and provide sub-optimal and unstable estimates for nonlinear systems. It would be useful to have a controller that can handle both input constraints as well as being able to handle both linear and non-linear systems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate corresponding structural elements, and in which:

[0007] FIG. 1 is a diagram illustrating a wafer used in an overlay registration process.

[0008] FIG. 2 is a system diagram illustrating a controller embodiment.

[0009] FIG. 3 is a flowchart illustrating the control process of an overlay registration controller embodiment.

[0010] FIG. 4 is a flowchart of a controller process according to another overlay registration controller embodiment.

[0011] FIG. 5 is a diagram illustrating the operations of moving horizon estimation in one dimension.

DETAILED DESCRIPTION

[0012] The invention can be implemented in numerous ways, including as a process, a system, a composition of matter, a computer readable medium such as a computer readable storage medium or a computer network wherein program instructions are sent over optical or other communication links. In this specification, these implementations, or any other form the invention may take, are referred to as techniques. In general, the order of the steps of the processes may be altered within the scope of the invention.

[0013] A detailed description of one or more embodiments of the invention is provided with accompanying figures that illustrate the principles of the invention. The invention in connection with such embodiments, but the invention is not limited to any embodiment. The scope of the invention is limited only by the claims and the invention encompasses numerous alternatives, modifications and equivalents. Numerous specific details are set forth in the description in order to provide a thorough understanding of the invention. These details are for the purpose of example and the invention may be practiced according to the claims without all of these specific details. For the purpose of clarity, technical material that is known in the technical fields related to the invention has not been described in detail so that the invention is not unnecessarily obscured.

[0014] An improved technique for controlling registration overlay is disclosed. In some embodiments, the system performs a moving horizon estimation to estimate state, an input of the registration overlay using an objective function subject to constraints. In some embodiments, the estimated states are subject to state constraints. In some embodiments, the regulator objective function is minimized subject to input constraints. In some embodiments, the system employs an estimator objective function used to derive the optimal estimated states and a regulator objective function used to derive the optimal inputs based on the estimated states. Optimization problems may be solved using techniques including quadratic programming, linear programming, or any other appropriate techniques. In some embodiments, a state transition matrix is used to remove the steady-state offsets that are due to mismatch between predicted and measured measurements.

[0015] FIG. 2 is a system diagram illustrating a controller embodiment. The system model used to describe the relationship between lithography stepper 202 and overlay metrology tool 204. In this embodiment, the model is expressed as: $\dot{x} = Ax + Bu + y = Cx + \omega$

[0016] where A and B and C are model coefficients, x represents the state of the system, u represents the inputs of the system, y represents the outputs of the system, and ω represents noise that is present in the system. The inputs typically refer to system parameters that are manipulated by a user of the system. The states refer to information that characterizes the system. They typically have some correspondence with the inputs. The outputs typically refer to measurements taken on the system. The model of the system may vary for different embodiments. For example, it may be a linear function or a nonlinear function. Since the model coefficients typically are not perfect representations of the system being controlled, it is necessary to properly adjust the system to achieve desired outputs, measurements are taken during the control process to derive the coefficients and sometimes the model function itself. More details of the estimation process will be discussed below.

[0017] A regulator 200 is used to provide system inputs to drive the system states to a target. The regulator is given a target vector $z_{sub,k,sup,ref}$, which specifies the goal of the embodiment, the goal of the controller is to regulate the overall process to minimize errors, thus the target vector $z_{sub,k,sup,ref}$ is a vector of 0. Different target vectors are used in other embodiments. In this embodiment, the input, represented as a vector $u_{sub,k}$, is a vector of a lithography stepper 202 such as translational movement of the wafer in x and y, wafer rotation, reticle magnification, asymmetric magnification, reticle rotation, asymmetric rotation, as well as any other appropriate configuration parameters. The lithography stepper 202 provides the relative positioning of the wafer by adjusting the wafer, the mask or any other apparatus according to its input.

[0018] An overlay metrology tool 204 measures the position of the wafer and provides

y.sub.k. In some embodiments, y.sub.k is represented using misalignment vectors \hat{x} shown in FIG. 1. An estimator 206 reconstructs the system states and provides an estimated vector \hat{x} .sub.k based on the input of the lithography stepper u.sub.k, the model and the output y.sub.k. The states characterize the system, and may include parameters such as wafer translation in x and y directions, wafer scale in x and y directions, wafer rotation, nonorthogonality, reticle magnification, asymmetric magnification, reticle rotation, and wafer rotation, as well as process disturbances in the previously mentioned states. A state may have certain correspondence to the inputs, and in some embodiments the states may share certain variables, they are not necessarily equivalent. For example, the state may be the degrees of rotation of the wafer while the input may indicate the number of rotations results in such a rotation.

[0019] The estimator is designed to find the most likely states given the model, the inputs, and the measured outputs. Typically, this is achieved by adjusting the model to fit measurements as best it can. An estimator objective function is typically formulated to minimize the difference between the measurements and the predictions subject to the constraints on the estimated states. The estimated states are sent back to regulator 200, which has a regulator objective function to express the performance objective of the controller. The regulator objective function is defined by the user. According to the regulator objective function, the regulator drives the states to desired targets z.sub.k.sup.ref based on the estimated state and computes a set of inputs for tracking z.sub.k.sup.ref closely, using the estimated state as the initial state for the optimization.

[0020] Ideally, the estimator would provide the optimal estimated states to the regulator. The regulator would then provide an input to minimize the misalignment errors and meet the target. In real systems, however, the regulator objective function is frequently subject to constraints that preclude such an optimal input from being usable. For example, an input may be that the magnification is between 0 and 1.0; therefore an optimal input with a magnification of 5.0 is not reasonable. The regulator's objective function explicitly takes into account the constraint and provides the best practical input.

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Full patent description for Control of overlay registration

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NAME

CITY

STATE

COUNTRY

Middlebrooks, Scott A.

Sandy

OR

US

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NAME

CITY

STATE

COUNTRY

Middlebrooks, Scott A..

Sandy

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